Review of a Round Robin on Thin Film Thermal Conductivity

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A round-robin to measure the thermal conductivity (κ) of SiO_2 thin films has taken place under the auspices of the Versailles Project on Advanced Materials And Standards (VAMAS)**.** Films with nominal thicknesses of 50 nm, 100 nm, 200 nm, and 500 nm, produced by oxidation of Si wafers, were distributed to 21 laboratories; 11 laboratories returned usable results. Each laboratory received a separate set of specimens. Eight measurement methods were used; each of the methods was used by a single laboratory except for the 3 omega method which was used by six laboratories. The results generally showed large inter-laboratory variations; however the measurements made by the 3 omega method agreed well with each other. If interface thermal resistance, *R*, is ignored, then κ calculated from the 3 omega data appears to decrease with decreasing film thickness. However, if we assume that *R* is finite and that κ and *R* are specimen independent, we obtain $\kappa(SiO_2) = 1.38 \pm 0.05$ $W \cdot m^{-1} \cdot K^{-1}$ at 20ºC which is almost equal to the handbook value 1.37 $W \cdot m^{-1} K^{-1}$; $R = (2.3 \pm 0.9) 10^{-8}$ $m^2 K \cdot W^{-1}$. The standard uncertainty of the mean value is the 95% confdence limit. Conclusions for the 3 omega method are: 1) inter-laboratory reproducibility is good; 2) uncertainty increases with decreasing film thickness; 3) *R* cannot be ignored; 4) the special techniques required for specimen preparation makes the procedure difficult to implement as a standard measurement method. 5) these conclusions are applicable only to the specimen-type used here (ie. SiO_2 on Si); use of other specimen-types would require further validation. An inter-laboratory comparison of the other methods could not be done because none was used by more than one laboratory.

Participants in the round robin: H. Wang of Oak Ridge National Laboratory, G. Chen of UCLA, H.B. Chae of Soonchunhyang University, A. Bullen and D.G. Cahill of the University of Illinois, T. Yamane from Toray Research Center, J.H. Kim, E.J. Gonzalez and A. Feldman of NIST, R. Kato from Ulvac Sinku-Riko, X. Xu of Purdue University, J. Lambropoulas of the University of Rochester, K.E. Goodson of Stanford University, and J. Hartmann and M. Reichling from the Free University of Berlin.